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Description

Method and arrangement for logging on a mobile unit at a fixed station

The present invention relates to ~~an arrangement and~~ a method and system for logging on a mobile unit at a fixed station for a transmission of data by radio, in which transmission the data ~~are~~ is transmitted in time slots on a ~~plurality~~ Number of carrier frequencies and the carrier frequency is changed from one time slot to the next in accordance with a predetermined sequence.

INSERT A

In the majority of cordless telephones currently available on the market, it is possible to serve more than one mobile unit from a fixed station. Often, a cordless telephone system is retrofitted by adding a further mobile unit to the already existing mobile unit or units. For this purpose, the new mobile unit must be logged on in the already existing cordless telephone system; i.e., in particular, at the fixed station. Logging on is, therefore, to be understood within the ~~terms~~ context of the present ~~description~~ Invention to mean that a mobile unit, in particular a further mobile unit, is logged on, in the sense of signing on, at the fixed station. ~~so that~~ As such, once logging on has taken place ~~said~~ the mobile unit can transmit, ~~in particular,~~ voice information data to the fixed station and receive it from the fixed station.

Problems are experienced if a so-called frequency hopping spread spectrum system is used as air interface and a mobile unit, in particular a further mobile unit, is to be integrated into such a system. A frequency hopping spread spectrum system is to be understood here as a system in which a plurality of carrier frequencies is available for transmitting data by radio and the carrier frequency used is changed from time to time, for example after each time slot or frame of the transmission. In particular, in a time division multiplex system (TDMA), the carrier frequency can be changed after each time slot or time frame of the time division

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multiplex transmission. Such a frequency hopping spread spectrum system has advantages to the extent that the energy of the entire radio transmission is distributed over all the carrier frequencies and thus one single carrier frequency less is loaded. This is important in particular if a generally available frequency band, such as the 2.4 0Hz 1524 (Industrial Scientific Medical) band is used in which an upper limit for the maximum energy occurring per carrier frequency is prescribed, in order to keep interference with other subscribers as low as possible.

A further advantage of the frequency hopping spread spectrum system is that the provision of a large number of carrier frequencies makes the system less susceptible to interference. Furthermore, the protection of the system against listening in by third parties is increased, since the third party does not usually know which carrier frequency is being changed to after a certain time period.

Even if a frequency hopping spread spectrum system has the abovementioned advantages, there is still the problem of synchronizing the carrier frequencies and in particular of changing the carrier frequencies when logging on a new mobile unit at a fixed station. It is in fact a precondition of logging on that the mobile unit to be logged on is capable of communicating with the fixed station, i.e. can precisely perform the change of carrier frequency.

WO 95/06377 teaches a method and an arrangement for transmitting data wirelessly between a mobile unit and a fixed station in time slots on a plurality of carrier frequencies, in which method and arrangement the carrier frequencies of a predetermined time period are changed in accordance with a predetermined sequence. To accomplish this, the mobile unit and the fixed station each comprise a device for outputting the predetermined sequence and an HF module for transmitting the data in the time slots.

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The object of the present invention here is to provide a method and an arrangement for logging on a mobile unit at a fixed station, which method and arrangement enable a mobile unit to be logged on at a fixed station for a data transmission system, in which system data are transmitted in time slots on a plurality of carrier frequencies and the carrier frequency is changed from one time slot to the next.

This object is achieved according to the invention by means of a method for logging on a mobile unit at a fixed station for a transmission of data by radio, in

which transmission the data are transmitted in time slots on a plurality of carrier frequencies (TDMA system) and the carrier frequency is changed, for example, from one time slot to the next time slot in accordance with a predetermined sequence. According to the invention, check data which indicate the position of the carrier frequency of the current (instantaneously broadcast) time slot in the predetermined sequence are broadcast by the fixed station. The mobile unit can then determine the position of the carrier frequency of the current time slot in the predetermined sequence by means of the check data. The mobile unit to which, of course, the entire sequence is known, can then determine, on the basis of the position of the carrier frequency in the predetermined sequence, the carrier frequency which is to be changed to next, as a result of which synchronization of the change of the carrier frequency of the mobile unit with that of the fixed station is achieved.

The check data can, in particular, be transmitted only during a logging-on mode. After the logging-on mode has been terminated, normal transmission of, for example, voice information data between the mobile unit and the fixed station can then take place.

The carrier frequency change can be carried out by means of a sequence selected from a plurality of predetermined sequences. The check data can then indicate, beyond the position of the carrier frequency of the current time slot in the predetermined sequence, which of the plurality of predetermined sequences is selected and used.

The predetermined sequences can be determined in particular by means of an algorithm (hop algorithm).

It is possible to sense which of the plurality of carrier frequencies is subject to interference. During the logging on of the mobile unit at the fixed station, a carrier frequency which is prescribed by the predetermined sequence is also used if this carrier frequency has been sensed as being subject to interference. After the logging on has been concluded, that carrier frequency of

the predetermined sequence which is subject to interference is passed over during the normal transmission of data. This ensures that during the logging on mode the carrier frequency change prescribed by the predetermined sequence is strictly carried out, in order to ensure that the frequency of the mobile unit is synchronized with that of the fixed station in the sense of logging on.

In particular, the so-called 2.4 GHz ISM frequency band can be used for transmission.

The number of available carrier frequencies can be at least 75 and in particular 96.

In addition, according to the invention an arrangement for wire-free transmission of data between a mobile unit and a fixed station is provided. The fixed station here has an RF module for transmitting the data in time slots on a plurality of carrier frequencies in the sense of a time division multiplex system. A device stores a predetermined sequence in order to define a change of the carrier frequency, for example from one time slot to the next, and outputs this predetermined sequence to the RF module. The data broadcast by the fixed station have check data which indicate the position of the carrier frequency of the current time slot in the predetermined sequence. The mobile unit has a device for determining the position of the carrier frequency of the current time slot in the predetermined sequence by means of the check data.

As an alternative, the check signal can also specify the carrier frequency which the base station will "jump to" next.

As a further alternative, the check data can specify which carrier frequency the base station will use in the m-th time slot or m-th frame. This is advantageous if a mobile unit is in the so-called idle-locked or multiframe mode. In such a mode, a mobile unit resynchronizes with the base station only in every m-th time slot or frame if said mobile unit is not in the process of active voice communication with the base station.

The check data do not have to be broadcast in

every time slot or frame. If a mobile unit which would like to synchronize with a base station receives a time slot or frame which does not contain check data, it scans all the carrier frequencies again, this procedure being repeated until the mobile unit receives from the base station a time slot or frame which contains the check data.

The fixed station can have a switching device for switching over between a logging-on mode, in which a mobile unit, or a further mobile unit, can be logged on at the fixed station, and a normal transmission mode for normal transmission of information data. The check data are broadcast automatically only if the switching device is switched to the logging-on mode.

In the normal transmission mode, the check data are not broadcast, or are only broadcast on request.

A plurality of predetermined sequences can be provided in the output device. The check data then have data which go beyond the position data and which indicate the sequence currently in use.

The output device can have a processor which calculates the predetermined sequence by means of an algorithm.

The invention will now be explained in more detail by means of an exemplary embodiment and with reference to the accompanying figures, in which:

Fig. 1 shows an arrangement according to the invention for transmitting data in a wire-free fashion,

Fig. 2 shows a time frame of a data transmission standard such as is used in the present invention,

Fig. 3 shows a detailed illustration of a time frame according to the invention, for a carrier frequency, and

Fig. 4 shows a schematic representation of a frequency hopping spread spectrum system.

With reference to Fig. 1, the general design of the arrangement according to the invention for radio transmission will be explained firstly. As is generally customary, the arrangement for the transmission of data by radio has a fixed station 1 and a plurality of mobile units (mobile stations, cable-free telephones) 2, 3, 11. The fixed station 1 is connected here to the landline network with a terminal line 10. The fixed station 1 has an antenna 6 by means of which it is possible to communicate, for example, with the mobile unit 2 via a radio transmission path 8 or with the mobile unit 3 via a radio transmission path 9. The mobile units 2, 3, 11 each have an antenna 7 for receiving and transmitting data.

The internal design of a fixed station 1, insofar as it is of significance for the present invention, will now be explained in more detail. A processor 15 which determines a predetermined sequence by means of a predetermined algorithm (hop algorithm) is provided in the fixed station 1. As an alternative, a plurality of different algorithms may be provided in the processor 15, so that the processor 15 can determine different sequences in accordance with the respectively used algorithm. The sequences determined by the processor 15 are then transmitted to a storage and output device 13. The storage and output device 13 transmits to an RF module 4 either the sequence which is continuously determined by the processor 15 or a sequence which has been previously permanently stored in it.

The RF module 4 receives and transmits data on a carrier frequency f_x which depends on the current value of the sequence transmitted from the storage and output device 13. Therefore, a radio transmission takes place on a carrier frequency f_x, the currently used carrier frequency either being determined indirectly by the processor 15 by means of an algorithm or, alternatively, being determined directly from the value of a sequence

which has been permanently stored in the storage and output device 13.

The internal design of a mobile radio unit, insofar as it is relevant to the present invention, will now be described in more detail. In this respect, the design of a mobile radio unit 2, 3, 11 is essentially symmetrical to the internal design of the fixed station 1 described above. That is to say each mobile radio unit 2, 3, 11 has, as illustrated in the invention only for the mobile radio units 2 and 11, a processor 16. This processor 16 determines, by means of one, or alternatively by means of a plurality of available hop algorithms, a sequence which it transmits to a storage and output device 12. The storage and output device 12 transmits to an RF module 5 either the values of the sequence based on the algorithm which are determined continuously by the processor 16 or, alternatively, values of a sequence which has been permanently stored in it. The RF module 5 transmits or receives data on a carrier frequency f_x whose level depends on the value of the sequence transmitted to it by the storage and output device 12. A mobile unit 2, 3, 11 therefore receives or transmits data on a carrier frequency f_x whose level depends either on the current value of the sequence determined by the processor 16 or on the value of a sequence which has been permanently stored in the storage and output device 12.

It is to be noted here that the processor 15 in the fixed station 1 and the processors 16 in the mobile units 2, 3, 11 are based on the same algorithm for determining sequences, or in the event that a plurality of algorithms are available, have the same selection of algorithms. In the event that the sequence is not determined continuously by the processor 15, 16 but rather permanently prescribed in the storage and output devices 12, 13, the sequence which is stored in the storage and output device 13 of the fixed station 1 is of course identical to the sequences which are respectively stored in the storage and output devices 12 of the mobile units

2, 3, 11.

A transmission standard such as is used in the present invention will now be explained with reference to Fig. 2. As is clear in Fig. 2, data are transmitted in chronological succession in a plurality of time slots, 24 time slots Zx in the case illustrated, using the time division multiplex method TDMA (Time Division Multiple Access) on a plurality of carrier frequencies f_x, of which ten are illustrated. In the case illustrated, duplex mode is used on the carrier frequencies. This means that after the base station has transmitted the first twelve time slots Zx, it switches to reception and it receives the second twelve time slots (13 - 24) in the opposing direction.

In the event that the so-called DECT Standard is used for transmission, the chronological duration of a time frame is 10 milliseconds, and 24 time slots Zx are provided, namely twelve time slots for the transmission from the fixed station to mobile units and a further twelve time slots Zx for the transmission from the mobile units to the fixed station. In the DECT Standard, 10 carrier frequencies f_x between 1.88 GHz and 1.90 GHz are provided.

However, the present invention is also used in particular for transmission in the so-called 2.4 GHz ISM (Industrial Scientific Medical) frequency band. The ISM frequency band has a bandwidth of 83.5 MHz. In accordance with the specification "FCC Part 15" (Federal Communications Commission), at least 75 carrier frequencies must be distributed over these 83.5 MHz. Distributing the 83.5 MHz bandwidth over 96 carrier frequencies, i.e. a channel spacing of 864 kHz, is particularly advantageous.

The abovementioned frequency bands and standards are mentioned purely by way of example. The only fundamental precondition for the invention is that a so-called frequency hopping spread spectrum is used, i.e. a plurality of carrier frequencies are available, and that the carrier frequency f_x selected for the transmission is changed from time to time. A precondition of such a

change is that the data are transmitted in time slots Zx (time division multiplex method). The so-called DECT Standard as well as any other modified standard based on this DECT Standard, is therefore suitable. A modification can, in this respect, comprise, for example, a reduction (halving) in the number of time slots per frame, as a result of which the bit rate and consequently the necessary basic bandwidth of the transmission can be reduced (halved).

How the selection of a carrier frequency f_x for a specific time slot Zx is carried out will now be explained with reference to Fig. 4. It will be assumed that, at the time of the time slot Z1, the processor 15 of the fixed station 1 determines, on the basis of an algorithm, a value which the RF module 4 of the fixed station 1 converts indirectly into a carrier frequency f_1. In Fig. 4, the hatching shows that the carrier frequency f_1 is selected at the time of the time slot Z1. At the transition from the time slot Z1 to the following time slot Z2, the carrier frequency f_x is inevitably changed. As is illustrated by an arrow in Fig. 4, it is possible, for example, for the processor 15 of the fixed station 1 to determine by means of its algorithm a value which is converted by the RF module 4 into a carrier frequency f_3. In the same way, a carrier frequency f_2 can then be selected for the time slot Z3, which is illustrated by hatching and by an arrow.

In the example above, the case was explained in which the carrier frequency is changed after a time slot in each case. However, for the invention it is only significant that the change of the carrier frequency takes place in each case after a predetermined time period. This may also be, for example, a frame.

The fixed station 1 therefore changes the carrier frequency f_x from the carrier frequency f_1 to the carrier frequency f_3 and then to the carrier frequency f_2 on the basis of the sequence determined by the processor 15. If communication is to take place between the fixed station 1 and a mobile unit 11, it is necessary to ensure that

the mobile unit 11 can follow synchronously the sequence of carrier frequency f_x changes carried out by the fixed station 1. This is a problem in particular when a mobile unit 11 is to be first integrated into a radio transmission system, i.e. has to be logged on and signed on at the fixed station 1. During unsynchronized operation of the new mobile unit 11 after it has been switched on, the mobile unit 11 will change the carrier frequencies f_x used, in the way prescribed by its sequence. The sequence as such is identical here with the sequence 1, which is prescribed in the fixed station 1 and explained above. However, this does not ensure that the sequence of the mobile unit 11 is synchronized with the sequence of the fixed station 1 after said mobile unit 11 has been switched on.

Fig. 3 illustrates how it is ensured according to the invention that the new mobile unit 11 carries out carrier frequency changes which are synchronous with the fixed station 1. As is clear in Fig. 3, the data transmitted in a time slot (channel) Zx are, for the most part, information data, i.e. for example data which represent an item of voice information of a telephone call. Before the range of the information data there is then a check range which is referred to as A field in the DECT Standard. In this check range, data are provided for synchronizing the operation of a mobile unit 11 to be logged on with the operation of the fixed station 1. If a plurality of algorithms are available to the processor 15 in the fixed station 1 for determining the sequence which directly prescribes the changes of the carrier frequency f_x of the fixed station 1, the check range contains data which identify the algorithm currently in use. Further synchronization data contained in the check range are data which indicate which position in the predetermined sequence corresponds to the carrier frequency f_x used for the current time slot Zx. The data of the check range which are illustrated in Fig. 3, namely data which refer to the algorithm used and which refer to the current position of the sequence of the

current algorithm, are broadcast by the fixed station 1 to the mobile unit 11.

As an alternative, the check signal can also specify the carrier frequency which the base station will "jump to" next.

As a further alternative, the check data can specify which carrier frequency the base station will use in the m-th time slot or m-th frame. This is advantageous if a mobile unit is in the so-called idle-locked or multiframe mode. In such a mode, a mobile unit resynchronizes with the base station only in every m-th time slot or frame if said mobile unit is not in the process of active voice communication with the base station.

The check data do not have to be broadcast in every time slot or frame. If a mobile unit which would like to synchronize with a base station receives a time slot or frame which does not contain check data, it scans all the carrier frequencies again, this procedure being repeated until the mobile unit receives from the base station a time slot or frame which contains the check data.

After it has been switched on, the mobile unit 11 scans the available range of carrier frequencies f_x until it senses the carrier frequency f_x currently being used by the fixed station 1. During this sensing of the carrier frequency f_x currently in use, the mobile unit 11 also senses the data of the check range of the data broadcast by the fixed station 1. At first, the mobile unit 11 can therefore determine which algorithm is currently being used by the processor 15 in the fixed station 1, said algorithm, of course, indirectly pre-scribing the charging of the carrier frequencies of the fixed station 1.

In addition the mobile unit 11 can therefore sense, from the position data of the check range, which position in the predetermined frequency corresponds to the broadcast carrier frequency. The mobile unit 11 is therefore then aware of the algorithm in use and of the

position in the sequence. The mobile unit 11 can then determine independently by means of the position in the sequence, which is known here, as well as the sequence stored in it, which carrier frequency f_x will be used by the fixed station 1 in the following time slot Z_x. From the information fed to it, the mobile unit 11 can therefore generate information for the carrier frequencies to be used in the following time slots Z_x. Thus, it is possible to communicate with the fixed station 1, as is necessary for a signing-on or logging-on procedure. As a result of the information supplied relating to the future carrier frequency change, the mobile unit 11 is therefore then synchronized with the fixed station 1.

The fixed station 1 can have a switching device 14 which can be switched between two positions, namely a position in the logging-on mode R and a position corresponding to the normal transmission mode. Only if the switching device 14 is switched to logging-on mode R does the fixed station 1 automatically broadcast the check range data necessary for synchronization with a mobile unit to be newly logged on, this data being namely the information relating to the algorithm in use and the information relating to the position in the predetermined frequency on the basis of the algorithm. If the switching device 14 is switched to the normal transmission mode N, the aforesaid synchronization data are normally not broadcast, that is only broadcast on request from a mobile unit.

A problem when logging on a further mobile unit 11 can result from a so-called noise source fall-back mode. Firstly, it will be explained what action the fixed station 1 takes in accordance with this noise source fall-back mode with regard to the carrier frequency selection. With reference to Fig. 4 it is clear that at the time of the time slot Z3 the carrier frequency f_2 is indicated by the predetermined frequency. It will now be assumed that the predetermined sequence for the time of the time slot Z4 indicates a change to the carrier frequency f_4. In addition, it will be assumed that, for

example in the preceding time frame of the transmission, the fixed station 1 has determined that interference occurred during a transmission on the carrier frequency f_4. This interference may result, for example, from the fact that another radio transmission arrangement is adversely affecting this carrier frequency f_4. If the fixed station 1 is in the so-called noise source fall-back mode, when selecting the carrier frequency f_x for the time slot Z4 it will not select the carrier frequency f_4 which is, of course, actually prescribed by the predetermined frequency. The carrier frequency f_4 which is sensed as being subject to interference is instead passed over and another carrier frequency f_x, for example the carrier frequency f_x which follows in the predetermined frequency, is selected for the time slot Z4 (as illustrated by the arrow P_1). In the case illustrated in Fig. 4, the carrier frequency selected for the time slot Z4 is therefore not the carrier frequency f_4 which is sensed as being subject to interference but instead the carrier frequency f_1 which is sensed as being free of interference.

Even if this noise source fall-back mode has, of course, large advantages during the radio transmission mode with mobile units 2, 3 which have already been integrated, it is clear that this noise source fall-back mode simultaneously causes large problems for the logging on of a new mobile unit 11. The mobile unit 11 will, in fact, determine, on the basis of the algorithm stored in it and the position of the carrier frequency, known to it from the check range of the data transmitted from the fixed station, in the predetermined sequence in accordance with the algorithm at the time of the time slot Z3, that a transmission on the carrier frequency f_4 will take place starting from the next value of the sequence at the time of the time slot Z4. However, if, owing to the noise source fall-back mode, the fixed station 1 selects the carrier frequency f_1 at the time of the time slot Z4 in order to avoid the carrier frequency f_4 which is subject to interference, and at the same time the mobile unit 11

to be logged on selects, on the basis of the information available to it, the carrier frequency f_4 at the time of the time slot Z4, synchronization of the operation of the fixed station 1 with that of the mobile unit 11 fails. If, for this reason, the logging-on mode R is selected by the switching device 14 in the fixed station 1, the noise source fall-back mode of the fixed station 1 is simultaneously switched off. This means that, in contrast with the normal mode in which, as stated above, the fixed station 1 will, in order to avoid the carrier frequency f_4 which has been recognized as being subject to interference, switch, in a position of the switching device 14 in logging-on mode R, to the carrier frequency f_4 at the time of the time slot Z4 as is prescribed by the sequence on the basis of the algorithm of the processor 15, although the fixed station 1 is aware that the carrier frequency f_4 is subject to interference. The change of the carrier frequency f_x from time slot Z3 to time slot Z4 is illustrated in Fig. 4 by the unbroken arrow P_2. As a result of the fact that the noise source fall-back mode of the fixed station 1 is simultaneously switched off when the switching device 14 is positioned in logging-on mode R, it is therefore ensured that a synchronization of the operation of the mobile unit 11 with that of the fixed station 1 can take place. After the signing-on procedure or logging on of the mobile unit 11 at the fixed station 1 has been completed, the switching device 14 is then switched back from the logging-on mode R to the normal transmission mode N, which can take place in an automated way, and the noise source fall-back mode can thus be switched on again automatically.

However, the noise source fall-back mode can also remain switched on during the signing-on procedure. In this context, it is to be noted that, in accordance with the exemplary embodiment, 96 carrier frequencies are provided, of which a maximum of 21 can be locked out, in order to avoid infringing the US-American Specification "FCC part 15". Therefore, the mobile unit knows the majority of carrier frequencies used, even in the noise

source fall-back mode. Thus, if communication does not come about between the mobile unit and the fixed station in a frame owing to a frequency lock-out which is not known to the mobile unit, in all probability it will be possible to resume communication in the next frame with a new carrier frequency.

Therefore, according to the invention, a method and a device for ensuring synchronism during the initial logging on of a new mobile unit at a fixed station is provided with a so-called frequency hopping spread spectrum system on a time division multiplex basis.

List of reference symbols

1: Fixed station
2: Mobile unit (cable-free telephone)
3: Mobile unit
4: RF module (in the fixed station)
5: RF module (in the mobile unit)
6: Antenna (in the fixed station)
7: Antenna (in the mobile unit)
8: First radio transmission path
9: Second radio transmission path
10: Terminal line
11: Mobile unit
12: Output device (in the mobile unit 11)
13: Output device (in the fixed station 1)
14: Switching device
15: Processor (in the fixed station)
16: Processor (in the mobile unit)
f_x: Carrier frequency
Zx: Time slot
P_1: Frequency change (noise source fall-back mode on)
P_2: Frequency change (noise source fall-back mode off)